Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Avian Predation on Juvenile Salmonids in the Lower Columbia River: Phase II - Management and Evaluation

Bonneville project number, if an ongoing project 9702400

Business name of agency, institution or organization requesting funding
Oregon State University/Columbia River Inter-Tribal Fish Commission

Business acronym (if appropriate) OSU/CRITFC

Proposal contact person or principal investigator:

Name	Dr. Daniel D. Roby
Mailing Address	Oregon Cooperative Wildlife Research Unit, Dept. of Fisheries and Wildlife, 104 Nash Hall, Oregon State University
City, ST Zip	Corvallis, OR 97331-3803
Phone	(541) 737-1955
Fax	(541) 737-3590
Email address	robyd@ccmail.orst.edu

Subcontractors. List one subcontractor per row; to add more rows, press Alt-Insert from within this table

Organization	Mailing Address	City, ST Zip	Contact Name
Columbia River Inter-Tribal Fish Commission	729 N.E. Oregon, Suite 200	Portland, OR 97232	Ken Collis

NPPC Program Measure Number(s) which this project addresses.
5.7A.6, 5.7B.20, 5.7B.21, 5.7B.22, 5.7B.23

NMFS Biological Opinion Number(s) which this project addresses.

1995 NMFS Hydrosystem Operations Biological Opinion: VII.A.14, XII.8, XII.9

Other planning document references.

If the project type is "Watershed" (see Section 2), reference any demonstrable support from affected agencies, tribes, local watershed groups, and public and/or private landowners, and cite available documentation.

NMFS Snake River Recovery Plan: V.2.8.a.2, V.2.8.b.1; Wy Kan Ush Me Kush Wit: 5.B.Hypothesis 6

Subbasin.

Work will be conducted on the lower Columbia River from the estuary to the head of McNary Pool. Benefits derived from management of bird predation could affect juvenile salmonids from any sub-basin within the foraging range of piscivorous waterbirds nesting in the study area.

Short description.

Develop a management plan to reduce avian predation on juvenile salmonids. Implement chosen management options and evaluate their efficacy through continued monitoring of smolt losses to birds. Continue to monitor piscivorous waterbird populations not targeted for management in FY99, if deemed necessary.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
*	Wildlife		Production		Population dynamics
*	Oceans/estuaries	*	Research		Ecosystems
	Climate	*	Monitoring/eval.	X	Flow/survival
	Other	X	Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.

predation, piscivorous waterbirds

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9008000	Columbia Basin PIT Tag Information System	Recovery of PIT tag codes from piscivorous waterbird colonies to be included in the PITAGIS database.
9600800	PATH	Measures of avian predation affect survival estimates of juvenile

		salmonids in mainstem passage models.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Develop and implement a management plan to reduce avian predation on juvenile salmonids	a	Coordinate all management activities with regional fish and wildlife managers and stakeholders
		b	Implement chosen management options
		c	Refine and further develop management options (i.e., adaptive management), as needed
2	Evaluate the efficacy of management options by monitoring changes in piscivorous waterbird population size, nesting distribution, productivity, diet, and foraging activity.	a	Conduct surveys to assess changes in size and distribution of piscivorous waterbird nesting colonies.
		b	Determine changes in diet composition and smolt consumption rates of managed piscivorous waterbirds
		c	Measure change in productivity of managed piscivorous waterbird colonies
3	Evaluate various environmental factors as they affect avian predation rates	a	Conduct surveys to determine size and distribution of piscivorous waterbird foraging concentrations
		b	Assess the relative importance of various environmental factors, including management, on foraging activity of piscivorous waterbirds
4	Monitor piscivorous waterbird populations not targeted for management in 1999, if deemed necessary.	a	Conduct surveys to locate and estimate the size of piscivorous waterbird colonies.
		b	Determine diet composition of piscivorous waterbirds and estimate their consumption rates of

			juvenile salmonids

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	12/1998	12/1999	30%
2	3/1999	8/1999	30%
3	3/1999	8/1999	30%
4	4/1999	8/1999	10%

Schedule constraints.

The implementation of a management plan to reduce predation by piscivorous waterbirds on juvenile salmonids will depend on decisions made by regional fish and wildlife managers and stakeholders, specifically (1) is there sufficient data to warrant management action, (2) what level of predation on juvenile salmonids warrants management of bird populations, and (3) what management options are most appropriate. These issues will be addressed in a workshop planned for December 1998. The schedule for FY99 could be affected if resource management agencies and stakeholder groups have difficulty reaching a consensus on the above mentioned management questions.

Completion date.
2001

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$70,000
Fringe benefits		$25,000
Supplies, materials, non-expendable property		$25,000
Operations & maintenance	includes $30,000 to BPA to cover costs of aerial surveys	$40,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$0
PIT tags	# of tags:	
Travel		$5,000
Indirect costs		$35,000
Subcontracts	CRITFC	$150,000
Other		
TOTAL		$350,000

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$350,000	$200,000	$0	$0
O&M as % of total	0%	0%	0%	0%

Section 6. Abstract

Piscivorous waterbirds can have a significant impact on survival of juvenile salmonids in mainstem Columbia and Snake rivers. Data collected in 1997 indicated that one bird colony in the Columbia River estuary consumed 6-20 million smolts. Recovery Plans for Columbia Basin salmonids have recommended that avian predation be thoroughly investigated and managed if necessary. In FY99, we will develop and implement a management plan to reduce avian predation on juvenile salmonids, should predation rates be deemed unacceptable. We will evaluate the efficacy of management initiatives and monitor the responses in targeted populations of piscivorous waterbirds (i.e., cormorants, terns, gulls) and their diets. We will use a bioenergetics approach to monitor the numbers of juvenile salmonids consumed by managed colonies of fish-eating waterbirds in the lower Columbia River (Columbia River estuary to head of McNary Pool). We will also assess those conditions and locales where avian predation on smolts continues to be most prevalent, and test the feasibility of potential new management techniques. Finally, we will continue to monitor population size and diet composition of those fish-eating waterbirds in the Lower Columbia River that could potentially contribute to significant smolt mortality. This project focused on assessing the magnitude of avian predation on juvenile salmonids in FY97 and FY98. Field work can be completed in 2 more years (FY99 and FY00) of implementing the management plan, unless otherwise indicated by the results, and final reports will be submitted one year following the completion of field work

Section 7. Project description

a. Technical and/or scientific background.

Published research suggests that avian predation can, under some conditions, be a substantial source of mortality for juvenile salmonids. Mace (1983) estimated that 10.4-31.7% of hatchery-released chinook smolts in the Big Qualicum River on Vancouver Island succumbed to avian predation within just 2 km of the hatchery. A subsequent study on the same river estimated that predation by merganser broods alone accounted for 24-65% of smolt production (Wood 1987b). Feltham (1995) estimated that mergansers removed 3-16% of smolt production on two Scottish rivers. In a 3-year study on the Penobscot River in Maine, predation by double-crested cormorants on hatchery-reared Atlantic salmon accounted for 7.5% to 9.2% of the run (Krohn and Blackwell 1996;

Blackwell 1995). Perhaps most impressive is the estimate by Kennedy and Greer (1988) that 51-66% of smolts from a wild run in an Irish river were lost to cormorant predation.

Available data suggest that predation is a major source of mortality for juvenile salmonids migrating through the mainstem Columbia and Snake rivers (Rieman et al. 1991; Ruggerone 1986; Bevan et al. 1994; Roby and Collis, unpubl. data). Aggregations of piscivorous birds have been observed on the Columbia River near dams (Ruggerone 1986; Steuber et al. 1993; Jones et al. 1996), at hatchery (Schaeffer 1991; Schaeffer 1992) and barge release points (K. Collis, CRITFC, pers. obs.), and in the estuary (Bevan et al. 1994) near the large waterbird breeding colonies at Rice and East Sand islands. Predation by birds on radio-tagged chinook salmon smolts has been documented in the tailraces below The Dalles and John Day dams and in the Columbia River estuary (C. Schreck, OSU, pers. comm.). In 1995, 11.3% (11/97) of radio-tagged yearlings and 4.1% (4/71) of subyearlings fell prey to gulls below The Dalles Dam (J. Snelling, OSU, pers. comm.). In 1996 and 1997, between 10% and 30% of radio-tagged chinook yearlings that resided in the Columbia River estuary were consumed by terns or cormorants nesting in that area (C. Schreck, OSU, pers. comm.). Stratified, systematic sampling for juvenile salmonid PIT tags at the Rice Island Caspian tern colony indicated that more than 33,000 smolt PIT tags have been deposited on the island over the last 10 years, and that millions of smolts were consumed by Caspian terns in both 1996 and 1997 (Collis and Roby, unpubl. data). The bioenergetics approach of estimating prey consumption yielded a preliminary estimate of 6-20 million juvenile salmonids consumed by the Rice Island Caspian tern colony in 1997 (Roby and Collis, unpubl. data). Currently, there is not enough information to estimate the number of salmon lost to other bird predators (i.e., double-crested cormorants and gull spp.; these data will be collected in FY98), but preliminary data suggest it is in the millions (Roby and Collis, unpubl. data). These data suggest that system-wide losses of juvenile salmonids to avian predators are likely to represent a significant proportion of the smolt out-migration.

Caspian terns (Sterna caspia) are one of the more important predators of juvenile salmonids in the Columbia River Basin. Caspian terns are the largest tern species in the world and are strictly piscivorous. Rice Island, a dredge material disposal island in the Columbia River estuary, is home to the largest Caspian tern colony in North America (over 9,000 nesting pairs; Collis and Roby, unpubl. data), and perhaps the world (F. Cuthbert, pers. comm.). Colony numbers have increased by more than 600% since the colony was first established in 1987 (G. Dorsey, USACE, pers. comm.). Two smaller Caspian tern colonies have become established above Bonneville Dam on Three Mile Canyon Island and Crescent Island, and appear to be increasing rapidly (photo census counts doubled and tripled, respectively, from 1996 to 1997). These two upriver tern colonies may be on the verge of exponential increases in colony size, similar to increases in the Rice Island Caspian tern colony in the late 1980's and early 1990's.

Double-crested cormorants (Phalacrocorax auritus) are a common piscivore in the lower Columbia River and estuary. Two large cormorant colonies have become established on a dredge-spoil island (Rice Island) and on a rock jetty at the west end East Sand Island, both in the Columbia River estuary. These two colonies, plus associated breeding pairs on nearby pilings and channel markers, supported a total population of roughly 7,500

breeding pairs in 1997 (Collis and Roby, unpubl. data). Annual aerial surveys conducted by the U.S. Fish and Wildlife Service from 1991-1995 and by BPA in cooperation with CRITFC and OSU in 1996 and 1997, indicated that this breeding population has increased by about 5% per year, and perhaps by as much as 25% in each of the last two years. This is consistent with continent-wide growth in double-crested cormorant populations and increasing frequency of conflicts with salmonid fisheries (Nettleship and Duffy 1995).

Gulls (Larus spp.) appear to be one of the most prevalent predators on juvenile salmonids throughout the Columbia River Basin, particularly on the lower Columbia River above Bonneville Dam (Jones et al. 1996, Ruggerone 1986). Two islands (Little Memaloose Island and Miller Rocks) created by The Dalles Dam impoundment support roughly 4,700 breeding pairs of California and ring-billed gulls (L. californicus and L. delawarensis, respectively), which are known to forage intensively on juvenile salmonids at The Dalles and John Day dams (J. Snelling, OSU, pers. comm.). Three Mile Canyon Island, created by the John Day Dam impoundment, supported a gull colony of approximately 13,300 breeding pairs in 1997, compared to 4,500 breeding pairs in 1978 (Thompson and Tabor 1981). Crescent Island, a dredge material disposal island near the mouth of the Walla Walla River, supports colonies of ring-billed and California gulls totaling about 5,700 nesting pairs in 1997. Two very large (i.e., totaling 33,000 nesting pairs) California and ring-billed gull colonies exist on two islands on the Columbia River near Richland, Washington. Each of these colonies have reportedly increased in size in recent years (E. Nelson, USFWS, pers. comm.).

Large breeding colonies of glaucous-winged/western gulls (L. glaucescens x L. occidentalis) are located on three islands in the Columbia River estuary. Although little is known about predation by glaucous-winged/western gulls on juvenile salmonids in the Columbia River estuary, they are opportunistic feeders and known to forage on smolts when they are locally abundant (Mossman 1959; Vermeer 1982). Given the numbers, population trajectories, species diversity, and wide distribution of avian predators on the lower Columbia River, total losses of juvenile salmonids to birds may now comprise a substantial proportion of each run.

As part of the 1994 Columbia Basin Fish and Wildlife Program, Bonneville Power Administration and other agencies have been charged with monitoring and assessing bird predation on juvenile salmonids in lower Columbia and Snake river reservoirs (5.7B.20) and in the Columbia River estuary (5.7B.21), and identifying non-lethal methods for control of piscivorous waterbird populations posing a problem to salmon survival (5.7B.22). This research (BPA-9702400) was initiated in FY97 to address the issue of avian predation on juvenile salmonids in the lower Columbia River. Work in FY97 and FY98 has focused on assessing the magnitude of avian predation and testing the feasibility of various non-lethal management alternatives to reduce predation by birds. In FY99, we propose to implement selected management options designed to reduce predation and to evaluate their efficacy. Furthermore, we plan to continue to monitor predation rates and size of un-managed piscivorous waterbird populations, if deemed necessary.

b. Proposal objectives.

The objectives of this study in FY99 are to (1) develop and implement a management plan to reduce avian predation on juvenile salmonids, (2) evaluate the efficacy of management options by monitoring changes in piscivorous waterbird population size, nesting distribution, productivity, diet, and foraging activity, (3) evaluate various environmental factors as they affect avian predation rates, and (4) monitor piscivorous waterbird populations not targeted for management in 1999, if deemed necessary.

Results from our field investigations in 1997 and 1998 will be used, along with agency and stakeholder input and published literature, to develop recommendations to reduce avian predation on juvenile salmonids (Objective 1), if warranted by the results. These recommendations will be specific to particular breeding colonies of piscivorous waterbirds where the impact on survival of juvenile salmonids has been demonstrated. The emphasis will be on management options that do not utilize direct destruction of the birds, their eggs, or their young, if such nondestructive options are feasible. These recommendations will be included as part of the FY98 Annual Report submitted to the funding agencies, as well as distributed to the federal and state agencies with management jurisdiction for salmon or the birds that prey on them (i.e., National Marine Fisheries Service, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife).

If management options are implemented, we will evaluate the effectiveness of these measures in reducing predation on juvenile salmonids (Objectives 2 and 3). Critical questions will be: (1) Did management reduce foraging activity in the area of concern?; (2) Did the managed population have fewer salmonids in their diet?; (3) Did productivity of the managed population change following management?; and (4) Was the management action successful in relocating the colony to an alternative location where its impact on smolt survival was greatly reduced? Answers to these questions will be used to refine and further develop management actions both within a field season and in outyears.

The impacts of other piscivorous waterbird colonies that are not managed in FY99 will be monitored (Objective 4) if it is determined that (1) insufficient data exist to justify management of those populations, or (2) there is potential for those populations to significantly impact salmon survival now or in the near future. Once it is determined that a piscivorous waterbird population poses no significant risk to salmon survival (e.g., number of salmonids consumed by the population is below some threshold value for more than one year), continued monitoring would no longer be recommended.

c. Rationale and significance to Regional Programs.

Regional plans for Snake River salmon recovery have recommended that avian predation be thoroughly investigated and managed if necessary (NPPC 1994, NMFS 1995,

CRITFC 1995). Available data suggest that predation is a major source of mortality for juvenile salmonids migrating through the mainstem Columbia and Snake rivers (Rieman et al. 1991; Ruggerone 1986; Bevan et al. 1994; Roby and Collis, unpubl. data). Anthropogenic perturbations to the Columbia River System have exacerbated predation-related mortality (Rieman et al. 1991; Li et al. 1987), and contributed to increases in populations of some predators (Beamesderfer and Rieman 1991; Gill and Mewaldt 1983). California and ring-billed gull numbers have increased dramatically with expanding irrigation-based agricultural development in the Columbia River Basin. New islands created by dredging and impounding the Columbia River have provided safe nest sites and attracted gulls and other colonial waterbirds to breed. Hatchery production, structures that affect smolt out-migration (e.g., hydroelectric dams, pile dikes), and releases of barged fish all provide excellent feeding opportunities for piscivorous waterbirds, possibly contributing to recent increases in waterbird populations. The breeding season of these piscivorous birds coincides with the period of out-migration of salmon smolts, potentially resulting in intense predation pressure in the vicinity of larger bird colonies.

Current management practices on the Columbia and Snake rivers offer many opportunities for predators to exploit salmon as a food source. Hydroelectric dams create "bottlenecks" to salmon migration and often injure or disorient out-migrating juvenile salmonids, increasing their vulnerability to avian predators. Hatchery and juvenile transportation practices that release salmonids en mass offer avian predators additional opportunities to exploit concentrated and vulnerable prey (Thompson 1959, Brown and Moyle 1981, Mace 1983, Collis et al. 1995, Shively et al. 1996). Control measures have previously been implemented to protect out-migrating juvenile salmonids from avian predators at most dams (i.e., bird wires, direct lethal control; Steuber et al. 1993, Jones et al. 1996). Some hatcheries are experimenting with different release strategies to reduce avian predation on hatchery-reared juvenile salmonids (i.e., nocturnal releases, releases on ebb tides; Schaeffer 1991; P. Pederson, WDFW, pers. comm.). Although there is evidence that some of these measures may be effective (Steuber et al. 1993, Jones et al. 1996), both the extent of predation-related mortality and the efficacy of control measures is largely unknown.

The 1994 Columbia Basin Fish and Wildlife Program has called for the monitoring and assessment of bird predation on juvenile salmonids in Columbia and Snake river reservoirs (5.7B.20) and in the Columbia River estuary (5.7B.21), as well as identification of non-lethal methods for control of piscivorous waterbird populations that pose a significant threat to smolt survival (5.7B.22). This research (BPA-9702400) addresses the issue of avian predation on juvenile salmonids in the lower Columbia River. Work in FY97 and FY98 has focused on measuring the significance of predation by different piscivorous waterbird populations and testing the feasibility of various non-lethal management alternatives to reduce predation by birds. In FY99, we propose to implement selected management options to reduce predation and evaluate their efficacy. Furthermore, we plan to continue to monitor predation by un-managed piscivorous waterbird populations, if deemed necessary.

d. Project history

In 1996, the CRITFC received funding ($20,589) from the Columbia Basin PIT-Tag Information System Project (BPA-9008000) to determine if PIT tags could be recovered from piscivorous waterbird breeding colonies. All recovered tag codes were provided to PSMFC and entered into the PITAGIS database. Also in 1996, BPA directly funded a photo census (project number and costs?) of all piscivorous waterbird breeding colonies in our study area based on our recommendations and guidance. That census produced a set of high resolution photos that were then analyzed to estimate the breeding population size at each colony. The results of the work completed in 1996 will be included in a subsequent report to the funding agencies in February 1998.

In 1997, the first year of project funding ($119,019, not including costs for aerial photo census and survey which was again funded directly by BPA), OSU/CRITFC were contracted to investigate the impacts of piscivorous waterbirds on the survival of juvenile salmonids on the lower Columbia River (BPA-55059000). Additional funds ($110,000) were provided by the USACE to look specifically at predation by Caspian terns nesting on Rice Island in the Columbia River estuary. The results of our work in 1997 will be included in the report mentioned above.

In 1998, OSU/CRITFC has proposed to continue their investigations of avian predation on juvenile salmonids with funds provided by BPA ($280,000 pending approval) and the USACE ($115,000; FY98 is the last year of scheduled funding from the Corps). The focus of this work will be to test the feasibility of various management options to reduce avian predation. Additionally, we will continue to investigate the relative impacts of different predator populations on salmon survival so that those populations posing the greatest risk can be targeted in future management actions (FY99). Results from this work, along with a management plan to reduce avian predation, will be included in a report submitted to the funding agencies in February 1999.

Preliminary results indicate that there are nine major breeding colonies of fish-eating birds that nest on islands in the lower Columbia River and Estuary. The majority of these islands are unnatural, created by either the dumping of dredge material or mainstem dam impoundments. Population censuses indicate that these bird populations are quite large (a total of roughly 150,000 breeding birds) and are increasing substantially each year. For example, Rice Island, a dredge material disposal island in the Columbia River Estuary, supports the largest Caspian tern colony in North America (over 19,000 birds) and has grown by over 600% since it was established in 1987. Diet analysis indicates that juvenile salmon are an important part of the diet of piscivorous waterbirds nesting in the Columbia River Estuary. Of birds nesting in the estuary, Caspian terns appear to be most dependent on salmon (roughly 85% of their diet), followed by cormorants and gulls. Gulls nesting upriver appear to be the least reliant on salmon as a food source, perhaps due to high flows in 1997 and measures implemented at Columbia River dams to reduce bird predation. We estimate that 6 - 20 million juvenile salmonids were consumed by Caspian terns nesting on Rice Island in 1997. We do not have enough information to estimate the number of salmon lost to other bird predators (collection of these data is proposed in 1998), but preliminary data suggest it is in the millions.

e. Methods.

Objective 1. Develop and implement a management plan to reduce avian predation on juvenile salmonids.

Task 1.1. Coordinate all management activities with regional fish and wildlife managers and stakeholders.

Methods: Any plan to manage piscivorous waterbird colonies will require the approval of regional fish and wildlife agencies having jurisdiction over the affected populations. In FY98, we plan on preparing for, organizing, and holding a workshop involving representatives of regional fish and wildlife management agencies (i.e., NMFS, IDFG, ODFW, WDFW, USFWS), funding agencies (i.e., BPA, USACE), and other stakeholder groups to discuss avian predation on juvenile salmonids in the lower Columbia River and possible management options to reduce predation, if warranted by the results. The purpose of the workshop will be to work towards agency consensus on whether the magnitude of avian predation on juvenile salmonids warrants management of piscivorous bird populations, which bird populations should be the targets of management, and which management options should be used to reduce avian predation on juvenile salmonids. The results of this workshop and any consensus conclusions will be incorporated in the management plan for avian predation on juvenile salmonids, which will be included in our 1998 Annual Report. In FY99, we will continue to closely coordinate any management activities with regional fish and wildlife agencies and stakeholder groups, as deemed necessary.

Task 1.2. Implement chosen management options.

Methods: Results from our field investigations in 1997 and 1998 will be used, along with agency and stakeholder input and published literature, to develop recommendations to reduce avian predation on juvenile salmonids, if warranted by the results. These recommendations will be specific to particular breeding colonies of piscivorous waterbirds where the impact on survival of juvenile salmonids has been demonstrated. The emphasis will be on management options that do not utilize direct destruction of the birds, their eggs, or their young, if such nondestructive options are feasible. These management options have yet to be fully developed or tested, nor have criteria been established for the selection of appropriate management options to implement (planned for 1998; see above). In FY98, we will test the feasibility of the following management options to reduce avian predation on juvenile salmonids: (1) modification of nesting habitat at breeding colonies of fish-eating waterbirds to limit availability of nest sites and encourage adults to nest elsewhere, (2) biological control of fish-eating waterbirds at their breeding colonies by encouraging natural predators and kleptoparasites, and (3) provide quality alternative nesting habitat for fish-eating

waterbirds in locations where juvenile salmonids from the Columbia River Basin are less vulnerable to predation (see FY98 Project Proposal to BPA for further details on the testing of management alternatives). Efforts to translocate a colony will be coupled with efforts to prevent the colony from establishing itself at a new location within the lower Columbia River and estuary (see Task 2.1).

Task 1.3. Refine and further develop management options, as needed.

Methods: If management options are implemented, we will evaluate the effectiveness of these measures in reducing predation on juvenile salmonids (see tasks under Objectives 2 and 3). If necessary, management options will be refined and further developed both in-season and in outyears to achieve the desired result.

Objective 2. Evaluate the efficacy of management options by monitoring changes in piscivorous waterbird population size, nesting distribution, productivity, diet, and foraging activity.

Task 2.1. Conduct surveys to assess changes in size and distribution of piscivorous waterbird nesting colonies.

Methods: Surveys of the distribution and size of managed piscivorous waterbird colonies will be conducted following attempts to relocate the colony to alternative nesting locations (see Task 1.2). Ground-based and aerial surveys will be conducted to locate the translocated colony and once established on a new breeding ground outside the area of concern (i.e., outside the lower Columbia River and estuary where their impact to salmon survival is likely to be reduced), aerial photos will be taken to estimate breeding population size (see FY98 Project Proposal to BPA for further details on aerial survey techniques). In addition, 30 birds from each managed population will be radio-tagged during early nest establishment and prior to attempts to translocate the colony. The movements of the radio-tagged birds will be tracked from the air and ground both before and after colony translocation. Results from the radio tagging study will be used to locate any new breeding grounds either inside or outside the area of concern. If inside the area of concern, efforts will be made to prevent nesting at that location. Furthermore, results from the radio-tag study will be used to assess changes in foraging activity, range and habitat utilization associated with the colony translocation (see Task 3.1).

Task 2.2. Determine changes in diet composition and smolt consumption rates of managed piscivorous waterbirds.

Methods: Diet composition and smolt consumption rates of managed piscivorous waterbird populations will be compared before vs. after colony translocation. Colony based diet sampling (see FY98 Project Proposal to BPA for further detail on diet sampling) will be conducted both prior to colony translocation and after the colony is established outside the area of concern. Diet will be monitored to

assess whether the colony translocation had the desired affect in reducing (1) the proportion of the diet that is salmonids and (2) the total number of salmonids consumed based on calculations using a bioenergetics approach (see FY98 Project Proposal to BPA for further details on the bioenergetics approach). Results from the radio telemetry study (see Tasks 2.1 and 3.1) will be used to further assess changes in diet associated with colony translocation. Finally, the new colony location will be searched for salmon PIT tags (see FY98 Project Proposal to BPA for further details on PIT tag sampling) as means to identify changes in the relative importance of juvenile salmonids in the diet of the managed population.

Task 2.3. Measure change in productivity of managed piscivorous waterbird colonies.

Methods: Once the managed population has relocated its colony outside the area of concern, productivity of the birds nesting at the new colony location will be measured (see the FY98 Project Proposal to BPA for further details on methods to measure productivity). Nesting success will be compared before (i.e., in previous years) and after colony translocation and additional comparisons made to the productivity of other established colonies (i.e., from published literature) as a way to assess the suitability of the new site as a permanent nesting location for the birds. We will determine clutch size, hatching success, nestling survival rate, brood size at fledging (if possible), and overall nesting success (proportion of nests that had at least one egg that produced one or more fledglings; if possible) for a sample of nests on the colony.

Objective 3. Evaluate various environmental factors as they affect avian predation rates.

Task 3.1. Conduct surveys to determine size and distribution of piscivorous waterbird foraging concentrations.

Methods: In FY98, a road-based survey route will be designed in order to sample the range of foraging habitats and locales for piscivorous waterbirds that are available throughout the Columbia River estuary (e.g., deep-water channels, shallow sloughs, sheltered bays, points of land, etc.; see FY98 Project proposal to BPA for further details on methods). This survey will provide a baseline measure of habitat utilization and foraging activity for the targeted piscivorous waterbird population prior to management. We will repeat this survey in FY99 and compare with results from the previous year to assess changes in habitat utilization and foraging activity of the managed population associated with colony translocation. We will collect the same information on un-managed populations to assess annual variation in foraging activity and habitat utilization of those populations. In addition, 30 birds from each managed population will be radio-tagged during early nest establishment and prior to attempts to translocate the colony. The movements of the radio-tagged birds will be tracked from the air and ground both before and after colony translocation. Data will be collected to assess

changes in foraging range, activity, and habitat utilization associated with the colony translocation.

Task 3.2. Assess the relative importance of various environmental factors, including management, on foraging activity of piscivorous waterbirds.

Methods: Foraging activity and habitat utilization of managed and un-managed piscivorous waterbird populations will be measured as part of Task 3.1. Data will be collected on behavior and activity of piscivorous waterbirds (e.g., resting, commuting, searching, actively foraging). Multispecies aggregations will be noted as it relates to potential interspecific mutualistic or commensual foraging behavior. Foraging flocks and aggregations will be marked on maps, and conditions at the time of the survey will be recorded. Additional visits to designated observation sites will be made when special conditions prevail (e.g., hatchery or barge releases, extremely high or low tides). Numbers and species recorded at a site throughout the period of smolt out-migration will be analyzed using multivariate techniques in order to identify those factors influencing the distribution and numbers of piscivorous waterbirds at each site.

Foraging conditions can be inferred from the parental attendance, parental exchange rates, and activity of piscivorous waterbirds at the breeding colony, as well as the distribution and numbers of birds at foraging sites. For managed and un-managed populations, we will monitor nest attendance (% of time parents remain on or near the nest), parental exchange rates (frequency with which the two members of a pair relieve each other of nest attendance duties or deliver food to young), and activity (frequency of transfers of food to young) from blinds in order to minimize the risk of observer influence on bird behavior. Attendance, exchange rates, and activity levels will be analyzed with respect to time of day, tide stage, tide amplitude, season, weather, nearby smolt releases, river flow rates, and other environmental factors in order to assess the relative importance of these factors in influencing foraging success.

Objective 4. Monitor piscivorous waterbird populations not targeted for management in 1999, if deemed necessary.

Task 4.1. Conduct surveys to locate and estimate the size of piscivorous waterbird colonies.

Methods: The impacts of other piscivorous waterbird colonies not managed in FY99 will continue to be monitored (Objective 4) if it is determined that (1) insufficient data exists to justify management of those populations, and (2) there is potential for those populations to significantly impact salmon survival now or in the near future. Aerial photos will be taken to estimate breeding population size (see FY98 Project Proposal to BPA for further details on aerial survey techniques) and results compared to population estimates in previous years to determine population trajectory.

Task 4.2. Determine diet composition of piscivorous waterbirds and estimate their consumption rates of juvenile salmonids.

Methods: Colony-based diet sampling will be conducted on selected un-managed piscivorous waterbird populations to determine the proportion of their diet that is salmonids. If deemed necessary, a bioenergetics approach will be used to determine the number of juvenile salmonids consumed by the population. Finally, the colony will be searched for salmon PIT tags to assess the relative importance of juvenile salmonids in the diet (for further details on the above mentioned methods refer to the FY98 Project Proposal to BPA). The FY99 results on population trajectory (Task 4.1) and diet will be compared with results from previous years to determine if the un-managed population poses an increasing or decreasing risk to salmon survival, information that will be important in decisions regarding the necessity of future management and/or monitoring.

f. Facilities and equipment.

This work will be conducted out of a field station in Astoria, Oregon. Lab facilities will be provided by OSU in Corvallis and Oregon Department of Fish and Wildlife in Clackamas, Oregon . Two boats capable of handling conditions encountered on the Columbia River will be needed. The Oregon Cooperative Wildlife Research Unit has a 20 ft. Boston Whaler and a 18 ft. Alumiweld that are fully equipped. The Unit will provide both boats for use on the project in return for maintenance, repair, and/or replacement in the event of normal wear and tear, damage, or loss of these two watercraft and associated equipment (outboard motors, trailers, etc.).

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Section 8. Relationships to other projects

This project will be conducted cooperatively by the Oregon Cooperative Wildlife Research Unit at Oregon State University and the Columbia River Inter-Tribal Fish Commission. Additional cooperators for work on colonial waterbirds in the Columbia River estuary include the U.S. Fish and Wildlife Service (POC: Al Clark, Refuge Biologist), the Oregon Cooperative Fishery Research Unit (POC: Carl Schreck and Larry Davis), the National Marine Fisheries Service (POC: Dick Ledgerwood), and the Clatsop County Economic Development Council (POC: Jim Hill).

For work further up river, cooperators include the U.S. Fish and Wildlife Service (POC: Eric Nelson, Refuge Biologist), U.S. Army Corps of Engineers (POC: Robert Stansell, Gretchen Starke, and other Corps biologists), and the Oregon Cooperative Fishery Research Unit (POC: Carl Schreck and John Snelling). Animal Damage Control (ADC) has been charged with implementing avian predation abatement measures at lower Columbia River Dams. We will work with ADC (POC: John Urquart) and the Corps (POC: Bob Cordie) to collect birds shot as part of this program for the purpose of determining diet of adult birds foraging at the dams. If requested, birds shot for diet analysis will be provided to the U.S. Fish and Wildlife (POC: Jeremy Buck) to measure body burdens of contaminants.

PIT tags recovered at Caspian tern colonies in 1998 will be sent to Pacific States Marine Fisheries Commission (POC: Carter Stein) for interrogation and inclusion in the PITAGIS data base. In return, PSMFC will provide us with information on individual PIT-tagged smolts (species, cohort, source, and run history) whose tags were recovered from the tern colonies in order to assess relative vulnerability to tern predation. Whole fish collected at the breeding grounds of piscivorous waterbirds will be provided to OSU (POC: Carl Schreck) to determine the incidence of BKD and other pathological conditions. We anticipate that additional collaborative and cooperative arrangements will be forged with other refuge managers and agencies currently engaged in or planning work on piscivorous birds on the lower Columbia River.

Section 9. Key personnel

Daniel D. Roby

Current Employment:
Associate Professor, Oregon Cooperative Wildlife Research Unit, Oregon State University, 1995-present
Project Title: Principle Investigator (0 FTE; time not charged to the project)
Education:
Ph.D, University of Pennsylvania (Biology), 1986
M.S., University of Alaska (Wildlife Management), 1978
B.A., Antioch College (Biology) 1974
Previous Employment:
Assistant Unit Leader - Wildlife, Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks,1992-1995
Assistant Professor of Zoology, Southern Illinois University, 1988-1992
Director, G.C.M. Wildlife Research Center, University of Rochester, 1986-1988
Publications:
Roby, D. D., J. R. E. Taylor, and A. R. Place. 1997. Significance of stomach oil for reproduction in seabirds: An interspecies cross-fostering experiment. Auk 114:725-736.
Roby, D.D. 1991. Diet and postnatal energetics in convergent taxa of plankton-feeding seabirds. Auk 108:131-146.
Roby, D.D. 1991. A comparison of two noninvasive techniques for measuring total body lipid in live birds. Auk 108: 509-518.
Roby, D.D., and R.E. Ricklefs. 1986. Energy expenditure in adult least auklets and diving petrels during the chick-rearing period. Physiol. Zool. 59:661-678.
Roby, D.D., and K.L. Brink. 1986. Breeding biology of least auklets on the Pribilof Islands, Alaska. Condor 88: 336-346.
Qualifications:
Dan Roby has been actively conducting research on the breeding biology and nesting ecology of colonial waterbirds for the last 20 years. His research has focused on the diet composition and reproductive energetics of seabirds, and how these factors influence nesting success. He has served as principal investigator on several major research projects with budgets in excess of $1 million, has been a PI on NSF-funded research, and is currently the PI for the Seabird Energetics component of APEX, a multi-million dollar integrated ecosystem project examining seabird-forage fish interactions in Alaska. He has published over 32 articles in peer-reviewed scientific journals, and he was the first or sole author on over half these articles. He is currently an Associate Professor of Wildlife Ecology (Courtesy) in the Department of Fisheries and Wildlife at Oregon State University, a Certified Wildlife Biologist with The Wildlife Society, and an Elected Member of the American Ornithologists' Union.

Ken Collis
Current Employment:
Fisheries Scientist, Columbia River Inter-Tribal Fish Commission, 1992-present
Project Title: Co-Principle Investigator/Project Manager (1 FTE)
Education:
M.S., University of Maryland (Behavioral Ecology), 1990
B.S. Lewis & Clark College (Biology), 1983
Previous Employment:

Environmental Biological Aid, Oregon Department of Fish and Wildlife, 1991
Bird Specialist, Victoria Forestry Commission, Queensland, Australia, 1985
Field Biologist, Point Reyes Bird Observatory, 1983-1984

Publications:

Collis, K., R.E. Beaty, and B.R. Crain. 1995. Changes in catch rate and diet of northern squawfish associated with the release of hatchery-reared juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 15(2): 346-357.

Authored or co-authored seven Annual Reports (re: tribal fisheries as part of the Columbia River Northern Squawfish Management Program) submitted to the Bonneville Power Administration over the past 5 years.

Collis, K. and G. Borgia. 1993. The costs of male display and delayed plumage maturation in the satin bowerbird (Ptilonorhynchus violaceus). Ethology 94: 59-71.

Collis, K. and G. Borgia. 1992. The age-related effects of testosterone, plumage, and experience on aggression and social dominance in juvenile male satin bowerbirds (Ptilonorhynchus violaceus). Auk 109: 422-434.

Borgia, G. and K. Collis. 1990. Parasites and bright male plumage in the satin bowerbird (Ptilonorhynchus violaceus). American Zoologist 30: 279-285.

Qualifications:

For the past 6 years, Ken Collis has been actively involved in predation research and management on the lower Columbia River. While working as Predation Project Leader for the CRITFC, Ken was responsible for the development, implementation, and evaluation of tribal fisheries (i.e., dam angling and site-specific gillnetting) for northern squawfish as part of the Columbia River Northern Squawfish Management Program. His work investigated the factors that influence predation rates by northern squawfish on juvenile salmonids and he used that information to develop effective management activities to reduce predation-related mortality on juvenile salmonids. Prior to his work in fisheries, Ken worked for six years studying behavioral biology in birds. Of particular relevance was his experience measuring productivity in seabirds on the Farallon Islands. He has published five articles in peer-reviewed scientific journals, both in fisheries and behavioral ecology (in birds).

Section 10. Information/technology transfer

The results from this research will be made available to the public through annual reports, a final completion report, and publications in peer reviewed scientific literature. In addition, the interim results of this research will be presented at meetings of professional societies at the regional, state, and national levels. The Avian Predation Management Plan produced as part of this work will incorporate input from research organizations, regional fish and wildlife management agencies, and other stakeholder groups. The implementation of selected management options to reduce avian predation on juvenile salmonids will likely require the approval of regional fish and wildlife agencies having jurisdiction over the affected populations. We will work closely with these groups (e.g., workshop to be held in December 1998) to achieve the project goals.